QUANTITATIVE ESTIMATION OF INDIVIDUAL RELIABILITY OF THE EQUIPMENT AND DEVICES OF THE POWER SUPPLY SYSTEM

Farhadzade E.M., Muradaliev A.Z., Farzaliev Y.Z.
Azerbaijan Scientific-Research and Design-Prospecting Institute of Energetic
AZ1012, Ave. H.Zardabi-94
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e-mail:fem1939@rambler.ru

ABSTRACT

The basic stages of a design procedure of parameters of individual reliability the equipment and devices of electro power systems are considered. The recommended method illustrated on an example of parameters of reliability calculated as average arithmetic random variables. The method based on imitating modeling of random variables and the theory of check of statistical hypotheses.

1. Statement of a problem and some definitions

The objective estimation of parameters of reliability (PR) the equipment and devices of electro power systems (EPS) always was and remains to one of priority problems which decision directed on decrease in expenses at designing and operation of electro installations [1]. In addition, despite of urgency of this problem, calculations PR, traditionally, spent for assumptions rather far from the validity. The basic assumption is the opportunity of representation of statistical data of operation by representative sample of general set of these data, i.e. these data represented homogeneous. Calculated PR thus carries, naturally, average character. At the same time dependence PR on those or other factors as a class of a voltage, type of the equipment, duration and conditions of operation, the system of service and so forth, that already contradicts this assumption is marked.

Set of the statistical data describing reliability of the equipment, actually represents so-called final set of multivariate data (MD) [2]. MD essentially differs from sample of general set. First, MD are set not only set of the random variables describing reliability of objects of research, but also set of versions of attributes (VA), describing each random variable. Practically, these data formed in the so-called empirical table which lines allocate objects, and columns: a serial number of objects, the attributes describing object, realizations of random variables and casual events. The set of objects is limited to frameworks of a solved problem and shown in set VA. But distinction not only in it.

It is known, that about reduction of number of random variables of sample of general set accuracy of estimations PR decreases (width of a confidential interval increases) [2]. At classification MD on set significant VA, decrease in number of realizations of a random variable in sample accompanied by decrease in disorder of possible values of a random variable, i.e. accuracy of estimations PR increases.

As an example, consider duration of restoration of deterioration at emergency repair (τ_{em}) witches of a power supply system. It is known, that with increase in a class of a voltage of switches average value of a random variable τ_{em} also increases. Thus, if values τ_{em} for air switches in final set of multivariate data change in an interval (6-105) hr., for air switches with nominal voltage (15-20)кV this interval appears essentially less and is equal (6-25) hr.

The account of these features allows passing from calculation of average values PR to calculation of parameters of individual reliability, i.e. PR for set VA. It is necessary to have in view of, that parameters of individual reliability, in fact, also are average. However, averaging here spent on "rustling" VA. Difficulty of an estimation of parameters of individual reliability in many respects caused by necessity of ranging set VA on their importance.

The problem of an estimation of parameters of individual reliability of the equipment from the methodical point of view is a special case of a problem of classification of park of objects on groups for which calculated PR differs not casually.

Significant interest at the decision of some operational problems caused with laws of change of parameters of individual reliability in function VA. The scale of these attributes can be not only in a quantitative kind (for example, service life, an interval of time after scheduled repair, etc.), but in serial (for example, a class of a voltage, capacity, etc.) and in nominal (for example, units of object, its importance, etc.). Difficulty of the decision of noted problems increases also because at the constant approach algorithms of estimation various PR are various.

2. Algorithm of comparison statistical functions of distribution final set MD and not casual sample of these MD.

Classification of statistical data on set VA, first, assumes an opportunity of an estimation of its expediency. One of ways of the characteristic of expediency of classification of data is the estimation of character of a divergence of statistical functions of distribution (s.f.d.) final set MD and sample of these MD on set VA. The approach to such comparison we shall consider on example PR, calculated as an average arithmetic X. Let us specify initial data:

- in the empirical table some final set MD of a random variable of X. Numerical value X is set depends from «n» considered attributes. Each of «n» attributes is presented to one of r_i VA with i=1,n.
  $F_\Sigma^*(X)$ - s.f.d., and $M_\Sigma^*(X)$ - average value of final set MD (index Σ carries parameters and characteristics of reliability to final set MD);
- certain combination VA sets object, PR that in the form of estimation $M_V^*(X)$ should estimated. Directly to estimate $M_V^*(X)$ it is impossible, since data about X at this object practically are absent. And without taking into account these VA, about any individuality to speak it is not necessary;
- not casual sample of values of random variable X, as result of classification MD on one VA is set. S.f.d. this sample we shall designate, as $F_V^*(X)$. To compare $F_\Sigma^*(X)$ and $F_V^*(X)$, we spend following sequence of calculations:

2.1. We count the greatest empirical deviation Δ.

For this purpose:

- for each value X_j from set $\{X\}_V$ samples it is defined absolute size of a deviation s.f.d. $F_\Sigma^*(X)$ from s.f.d. $F_V^*(X)$ under the formula

$$\Delta(X_j) = \left| F_\Sigma^*(X_j) - F_V^*(X_j) \right| \quad (1)$$

  with j=1,m, where m- number of realizations of random variable X in sample;
- define the greatest value among m realizations Δ(X) under the formula

$$\Delta_E = \max\{\Delta(X_1); \Delta(X_2); ...; \Delta(X_j); ...\Delta(X_m)\} \quad (2)$$

As distributions $F_\Sigma^*(X)$ and $F_V^*(X)$ constructed on statistically given operation, size Δ_E there is the greatest empirical deviation.

It is necessary to note, as statistics of criterion of a divergence can be chosen not only size Δ, but also average value of the greatest deviation Δ_{AV}, average quadratic value Δ_{AQ}., average geometrical value and a number of others. However, as shown in [4], statistics Δ has at the fixed value of a error of I type, the greatest capacity of criterion.

2.2. Modeling of distribution $F^*[\Delta(H_1)]$

S.f.d. $F^*[\Delta(H_1)] = P[\Delta < \Delta(H_1)]$- distribution of realization of absolute size of the greatest deviation of modeled realizations s.f.d. $F_V^*(X)$ from s.f.d. $F_\Sigma^*(X)$ for assumption H_1 (divergences of realizations s.f.d. $F_\Sigma^*(X)$ also $F_V^*(X)$ has casual character)

Modeling $F^*[\Delta(H_1)]$ spent in following sequence:

- on distribution, $F_\Sigma^*(X)$ it is modeled m random variables X. According to [3] calculation of realization of random variable X it is carried out under the formula
$$X = X_i + (X_{i+1} - X_i)[(n+1)\xi - i] \tag{3}$$
where ξ- proggrammatic a modeled pseudo-random variable with uniform distribution in an interval [0,1]. Let's designate this set of values X as $\{X\}_V^*$
- according to $\{X\}_V^*$ is under construction s.f.d. $F_V^{**}(X)$;
- transformation of final set MD is spent. For this purpose:
  - from set of values X of final set MD are withdrawn m the values describing $\{X\}_V$;
  - instead of $\{X\}_V$ values $\{X\}_V^*$ are entered;
  - pays off s.f.d. on transformed final set MD. Designate it is $F_\Sigma^{**}(X)$;
- for realizations of random variables X_j with j=1,m samples are calculated absolute deviations s.f.d. $F_\Sigma^{**}(X_j)$ and s.f.d. $F_V^{**}(X_j)$ under the formula:
$$\Delta(X_j) = \left|F_\Sigma^{**}(X_j) - F_V^{**}(X_j)\right|; \tag{4}$$
- the greatest deviation s.f.d. defined $F_\Sigma^{**}(X)$ from s.f.d. $F_V^{**}(X)$ under the formula
$$\Delta(H_1) = \max\{\Delta(X_1); \Delta(X_2); ...; \Delta(X_j); ...\Delta(X_m)\}; \tag{5}$$
- it is modeled N realizations of a random variable $\Delta(H_1)$;
- N realizations $\Delta(H_1)$ placed in ascending order. Further to each value $\Delta(H_1)$ the probability $F^*[\Delta_i(H_1)] = i/N$, where i–serial number of realizations of set of values is compared $\Delta(H_1)$. Calculations $F^*[\Delta(H_1)]$ come to the end with that.

2.3. Modeling of distribution $F^*[\Delta(H_2)]$**.**

S.f.d. $F^*[\Delta(H_2)] = P[\Delta < \Delta(H_2)]$- distribution of realizations of absolute size of deviations s.f.d. $F_V^*(X)$ from s.f.d. $F_\Sigma^*(X)$ for assumption H_2 (the divergence $F_\Sigma^*(X)$ and $F_V^*(X)$ is not casual). The algorithm of modeling $F^*[\Delta(H_2)]$ is similar to algorithm of modeling of distribution $F^*[\Delta(H_1)]$ with that essential difference, that modeling of sample from m values of random variable X is spent not on s.f.d. final set MD $F_\Sigma^*(X)$, and on s.f.d. $F_V^*(X)$.

2.4. Decision-making

To make a decision on character of a divergence $F^*_\Sigma(X)$ and $F^*_V(X)$, i.e. to choose one of two assumptions (H_1 or H_2) and by that to estimate expediency of classification of statistical data to the set attribute, it is necessary:

1. To define average value N of realizations $\Delta(H_1)$ under the formula

$$M^*[\Delta(H_1)] = \sum_{i=1}^{N} \Delta_i(H_1) \Big/ N$$

2. To define average value N of realizations $\Delta(H_2)$ under the formula

$$M^*[\Delta(H_2)] = \sum_{i=1}^{N} \Delta_i(H_2) \Big/ N$$

3. To construct s.f.d., describing error of I $\alpha^*(\Delta)$ and the II $\beta^*(\Delta)$ types

   3.1. If $M^*[\Delta(H_1)] < M^*[\Delta(H_2)]$, that

$$\alpha^*[\Delta(H_1)] = 1 - F^*[\Delta(H_1)] \qquad \beta^*[\Delta(H_2)] = F^*[\Delta(H_2)]$$

   3.2. If $M^*[\Delta(H_1)] > M^*[\Delta(H_2)]$, that

$$\alpha^*[\Delta(H_2)] = 1 - F^*[\Delta(H_2)] \qquad \beta^*[\Delta(H_1)] = F^*[\Delta(H_1)]$$

4. On s.f.d. $\alpha^*(\Delta)$ and $\beta^*(\Delta)$ to define critical values of absolute size of the greatest deviation $\Delta_{cr.}$. Size $\Delta_{cr.}$ in practice are calculated for the set significance values $\alpha_{cr.}$ and $\beta_{cr.}$, usually accepted equal $\alpha_{cr.}=\beta_{cr}=0.05$ (0.1). As actually distributions $\alpha^*(\Delta)$ and $\beta^*(\Delta)$ have discrete character, and among discrete values s.f.d., as a rule, there are no probabilities α_{cr} and β_{cr}, equal 0,05 or 0,1, recommended to accept as an admissible error of I type the nearest to α_{cr} smaller value among set of discrete values s.f.d. $\alpha^*(\Delta)$, and as an admissible error of II type - the nearest to β_{cr}, smaller value among set of discrete values s.f.d. $\beta^*(\Delta)$. The valid boundary values of these errors at $M^*[\Delta(H_1)] < M^*[\Delta(H_2)]$ designate accordingly: for a error of I type - through sh1[$\Delta(H_1)$], and for a error of II type – through sh2[$\Delta(H_2)$]. Corresponding sh1[$\Delta(H_1)$] critical value of the greatest deviation will be Δ_{cr}[sh1(H_1)], and for sh2[$\Delta(H_2)$] - will be Δ_{cr} [sh2(H_2)]. If $M^*[\Delta(H_1)] >$ $M^*[\Delta(H_2)]$ boundary values of these errors accordingly will be sh1[$\Delta(H_2)$] and sh2[$\Delta(H_1)$]. Corresponding mistakes of the first and second sort sh1[$\Delta(H_2)$] and sh2 [$\Delta(H_1)$] critical values of the greatest deviation will be Δ_{cr}[sh1(H_2)] and Δ_{cr}[sh2(H_1)]
5. To compare with an empirical deviation Δ_E with critical values of mistakes of the first and second sort. Thus

   5.1. If $M^*[\Delta(H_1)] < M^*[\Delta(H_2)]$ and $\Delta_E \geq \Delta_{cr}$[sh1($H_1$)], with a significance value sh1[$\Delta(H_1)$] assumption H_2 is accepted. If $M^*[\Delta(H_1)] >$ $M^*[\Delta(H_2)]$ and $\Delta_E \geq \Delta_{cr}$[sh2($H_2$)], with a significance value sh1[$\Delta(H_2)$] assumption H_1 is accepted

   5.2. If $M^*[\Delta(H_1)] < M^*[\Delta(H_2)]$, and $\Delta_E < \Delta_{cr}$sh1(H_1)] and $\Delta_E \leq \Delta_{cr}$[sh2($H_2$)], with a significance value sh2[$\Delta(H_2)$] assumption H_1 is accepted. If $M^*[\Delta(H_1)] > M^*[\Delta(H_2)]$, and $\Delta_E < \Delta_{cr}$[sh1(H_2)] and $\Delta_E \leq \Delta_{cr}$[sh2 ($H_1$)], with a significance value sh2[$\Delta(H_1)$] assumption H_2 is accepted

The total risk of the erroneous decision pays off under the formula:

$$Ri(\Delta) = A \cdot F[\Delta(H_1)] + B \cdot F[\Delta(H_2)] = Ri[\Delta(H_1)] + Ri[\Delta(H_2)]$$

where A and B – factors of the importance of errors of I and II types; A+B=1. If the information on consequences of possible errors of I and II types is absent, is accepted A=B=0.5, and Ri(Δ) calculated as an average arithmetic errors of I and II types.

Choice of one of two assumptions is spent on following conditions:

$$\left.\begin{array}{l} \text{If } Ri[\Delta_E(H_1)] >> \mathrm{Ri}[\Delta_E(H_2)], \text{ that H=H}_1 \\ \text{If } \mathrm{Ri}[\Delta_E(H_2)] >> Ri[\Delta_E(H_1)], \text{ that H=H}_2 \\ \text{If } \mathrm{Ri}[\Delta_E(H_1)] \cong Ri[\Delta_E(H_2)], \text{ that H=H}_1 \end{array}\right\} \quad (6)$$

As an example in table 1 initial data are cited: final set MD $\{X\}_\Sigma$ and sample of these MD $\{X\}_V$, s.f.d. $F^*_\Sigma[X]$ and $F^*_V[X]$ and results of calculation Δ_E.

In table 2 results of calculations of critical values of the greatest deviation and risk of the erroneous decision are resulted. From this table it is evidently visible, that errors of I and II types should be calculated not proceeding from corresponding assumptions (H_1 and H_2), and proceeding from a parity of average values of a random variable of sets $\{X\}_\Sigma$ and $\{X\}_V$. Not the account this parity leads to essential decrease in significance values (errors of I and II types). Data of tables 1 and 2 testify to inexpediency of classification MD, i.e. $H \Rightarrow H_1$.

In table 3 results of calculation for a case, when $H \Rightarrow H_2$

Table 1

Illustration of calculation of the greatest empirical deviation

N	$\{X\}_\Sigma$	$F^*_\Sigma(X)$	$\{X\}_v$	$F^*_V(X)$	$\|\Delta(X)\|$
1	105.8	0.059			
2	109.6	0.118			
3	109.9	0.176			
4	110.3	0.235			
5	111.3	0.294			
6	111.7	0.353	111.7	0.333	0.02
7	112.7	0.412			
8	113.7	0.471	113.7	0.667	0.196
9	113.9	0.529			
10	114.7	0.588			
11	115.2	0.647			
12	115.5	0.706			
13	117.2	0.765			
14	117.4	0.824			
15	117.7	0.882	117.7	1.000	0.118
16	119.2	0.941			
17	119.6	1.0			

Note: Δ_E=0,196

3. Algorithm of a choice of the most significant VA

It would seem algorithm of a choice it is simple enough:

- it is necessary to receive not casual sample of data of final set MD on everyone VA;
- to compare $F^*_\Sigma(X)$ and $F^*_V(X)$;
- to define risk of the erroneous decision;
- to define VA with the minimal risk of the erroneous decision

However simplicity of algorithm is deceptive, since it is required to lead generally n! calculations, that on time exceeds comprehensible opportunities of computer facilities. The problem consists in comparison not casual выборок data on everyone VA. It is necessary to allocate sample, s.f.d. This to the greatest degree would differ from s.f.d. final set MD. The preference is given sample, numerical characteristics s.f.d. this to the greatest degree differed from numerical characteristics s.f.d. $F^*_\Sigma(X)$ in comparison with the others s.f.d. In particular considered:

Table 2

Illustration of calculation of critical values of the greatest deviation and risk of the erroneous decision

N	$\Delta(H_1)$	$F^*[\Delta(H_1)]$	$\Delta(H_2)$	$F^*[\Delta(H_2)]$	$\{1-F^*[\Delta(H_2)]\}$	$Ri^*(\Delta)$	Results of calculation
1	0.000	0.000	0.000	0.000	1.000	0.500	M*[Δ(H1)] = 0,271
2	0.020	0.003					M*[Δ(H2)] = 0,245
3	0.039	0.006					Sh1[Δ(H2)] = 0,023
4	0.059	0.012					Δ_{cr}[sh1(H2)] = 0,471
5	0.078	0.031					Sh2[Δ(H1)] = 0,045
6	0.098	0.045					Δ_{cr}[sh2 (H1)] = 0,098
7	0.118	0.097	0.118	0.150	0.850	0.474	$Ri^*(\Delta)$ = 0,433
8	0.137	0.140	0.137	0.206	0.794	0.467	$H \Rightarrow H_1$
9	0.157	0.214	0.157	0.332	0.668	0.441	
10	0.176	0.256	0.176	0.390	0.610	0.433	
11	0.196	0.355	0.196	0.475	0.525	0.440	
12	0.216	0.412					
13	0.235	0.460	0.235	0.568	0.432	0.446	
14	0.255	0.545	0.255	0.641	0.359	0.452	
15	0.275	0.622					
16	0.294	0.679	0.294	0.759	0.241	0.460	
17	0.314	0.728	0.314	0.798	0.202	0.465	
18	0.353	0.772	0.353	0.838	0.162	0.467	
19	0.373	0.806					
20	0.412	0.847	0.412	0.911	0.089	0.468	
21	0.431	0.876					
22	0.471	0.941	0.471	0.977	0.023	0.482	
23	0.490	0.966					
24	0.529	0.995	0.529	1.000	0.000	0.498	
25	0.549	1.000			0.000	0.500	

Table 3

Results of calculations of expediency of classification final set MD

N_Σ	$\{X\}_\Sigma$	N_V	$\{X\}_V$	Results of calculations
1	100	1	100	$M^*[\Delta_{(H1)}] = 0,188$
2	103	2	104,6	$M^*[\Delta_{(H2)}] = 0,269$
3	104,6	3	105,9	$\Delta_{Э}=0,265$
4	105,9	4	113,5	$Sh1[\Delta(H_1)] = 0,029$
5	107,3	5	116	$\Delta_{cr}[sh1(H_1)] = 0,265$
6	108,3	6	139,6	$Sh2[\Delta(H_2)] = 0,030$
7	109,7			$\Delta_{cr}[sh2(H_2)] = 0,147$
8	113,5			$Ri^*(\Delta) = 0,245$
9	114			$H \Rightarrow H_2$
10	116			
11	116,7			
12	118,9			
13	122,1			
14	132			
15	134,7			
16	139,6			
17	140,5			

– the greatest value of absolute size of distinction of average values of random variables of final set MD and samples of this set on each of set VA, calculated under the formula:

$$\Delta[M^*(X)] = \max\{\Delta_1[M^*(X)];\Delta_2[M^*(X)];...;\Delta_i[M^*(X)];...;\Delta_n[M^*(X)]\} \quad (7)$$

where: $\Delta_i[M^*(X)] = \left|M^*_\Sigma(X) - M^*_{V,i}(X)\right|$; i=1,n;

$$M^*_\Sigma(X) = \sum_{i=1}^{L} X_i \Big/ L; \qquad M^*_{V,i}(X) = \sum_{j=1}^{m_i} X_j \Big/ m_i$$

– the greatest value of absolute size of distinction of average quadratic deviations of random variables of final set MD and samples of this set on each of set VA, calculated under the formula:

$$\Delta[G^*(X)] = \max\{\Delta_1[G^*(X)];\Delta_2[G^*(X)];...;\Delta_i[G^*(X)];...;\Delta_n[G^*(X)]\} \quad (8)$$

where: $\Delta_i[G(X)] = \left|G^*_\Sigma(X) - G^*_{V,i}(X)\right|$; i=1,n;

$$G^*_\Sigma(X) = \left\{\frac{\sum_{j=1}^{L}\left[M^*_\Sigma(X) - X_j\right]^2}{L-1}\right\}^{1/2}; \qquad G^*_{V,i}(X) = \left\{\frac{\sum_{j=1}^{m_i}\left[M^*_{V,i}(X) - X_j\right]^2}{m_i-1}\right\}^{1/2};$$

L – Number of random variables of final set MD; m_i – number of random variables of i-th sample

– the greatest value of absolute size of distinction of estimations of factors of a variation of final set MD and samples of this set on each of set VA, calculated under the formula:

$$\Delta[K^*(X)] = \max\{\Delta[K^*_1(X)];\Delta[K^*_2(X)];...;\Delta_i[K^*_i(X)];...;\Delta[K^*_n(X)]\} \quad (9)$$

where: $\Delta[K_i(X)] = \left|K^*_\Sigma(X) - K^*_{V,i}(X)\right|$; i=1,n;

$$K^*_\Sigma(X) = G^*_\Sigma(X) \Big/ M^*_\Sigma(X); \qquad K^*_{V,i}(X) = G^*_{V,i}(X) \Big/ M^*_{V,i}(X).$$

– the least relative value of disorder of random variables samples, calculated under the formula:

$$\delta(X) = \min\{\delta_1(X);\delta_2(X);........,\delta_n(X)\}$$

(10)

where: i=1,n; $\delta_i(X)=(X_{\max,V,i}-X_{\min,V,i})/(X_{\max,\Sigma}-X_{\min,\Sigma})$;

$$X_{\max,V,i}=\max\{X_{V,i,1};X_{V,i,2};.....X_{V,i,m_i}\};$$
$$X_{\min,V,i}=\min\{X_{V,i,1};X_{V,i,2};.....X_{V,i,m_i}\};$$
$$X_{\max,\Sigma}=\max\{X_{\Sigma,1};X_{\Sigma,2};.....X_{\Sigma,L}\};$$
$$X_{\min,\Sigma}=\min\{X_{\Sigma,1};X_{\Sigma,2};.....X_{\Sigma,L}\}.$$

Thus it was supposed, that if s.f.d. samples with extreme values of distinction of numerical characteristics casually differs from s.f.d. $F^*_\Sigma(X)$, casually differs from $F^*_\Sigma(X)$ and s.f.d. all others samples. How much this assumption is true? Experiences of calculations have allowed drawing following conclusions:

- by comparison $F^*_\Sigma(X)$ and $F^*_V(X)$ in a kind of small number of realizations of sample, there is an uncertainty of the decision caused by classification that testifies to inexpediency of classification. I.e. the preference given H_1. Here finds the reflection influence not so much numbers of random variables, how many sizes of their disorder concerning disorder of final set MD. It is established, that the importance VA above, the concerning the average value random variables of sample more concentrate on axes of set of values of final set MD. This conclusion explains cases of erroneous decisions on a condition (7)
- the average quadratic deviation characterizes disorder of random variables concerning their average value. Consequently, it should seem to carry out a choice of the most significant VA more authentically. But it has appeared that the decision depends on average value of sample and number of random variables. Than it is less $M^*_\Sigma(X)$ and more $M^*_{V,i}(X)$, and the number of random variables of sample is more, the reliability of the decision of a choice between H_1 and H_2 is more;
- the condition (9) in which basis there is a comparison of change of factors of a variation, eliminates dependence of estimations of an average quadratic deviation on average value of sample of random variables. Reliability of the decision in comparison with a condition (8) has increased. The condition (9) has eliminated the errors caused by influence of average values $M^*_\Sigma(X)$ and $M^*_{V,i}(X)$ with i=1,n, but has kept their dependence on number of random variables that is shown already at number of attributes i>3
- the condition (10), reflecting physical essence of importance VA, has appeared the most sensitive and authentic. It precisely proves to be true graphically by comparison s.f.d. $F^*_\Sigma(X)$ and $F^*_{V,i}(X)$ with i=1,n.

Thus, algorithm of definition of the most significant VA and consequently working sample, at each stage of classification MD it reduced to following sequence of calculations:

- formation (n+1-i) samples from final set MD of realizations of random variables X for set VA, where i- number simultaneously considered VA, i=1,n is spent;
- the interval of change of random variables X for final set MD and (n+1-i) samples is defined;
- under the formula (10) relative values of an interval of change of random variables in (n+1-i) samples are calculated and defined sample with the minimal value of relative value of an interval is δ(X);
- constructions under s.f.d. this sample $F^*_V(X)$ and final set MD $F^*_\Sigma(X)$

According to the algorithm stated in p.2 comparison s.f.d. is spent. $F^*_\Sigma(X)$ and $F^*_V(X)$.

4. The integrated algorithm of definition of parameters of individual reliability

The essence of algorithm reduced to following sequence of calculations:

- at the first stage most significant of VA defined. The methodology of the decision of this problem considered us in section 3. Designate the sample corresponding most significant VA as $\{X(i,j)\}_V$, where i=1,n. j=1,r$_i$, and a serial number of it VA - (i, j);
- check of assumptions of character of a divergence $F^*_\Sigma(X)$ is spent and $F^*_{V,P}(X)$. If assumption H$_2$ of difference $F^*_\Sigma(X)$ also $F^*_{V,P}(X)$ is rejected (theoretically it probably) and data do not contradict assumption H$_1$ of casual character of difference significant VA are absent, classification of final set MD is inexpedient, and PR are calculated on final set MD. If with the set significance value assumption H$_1$ is rejected and data do not contradict assumption H$_2$ we pass to the second stage of calculations;
- at the second stage calculations similar to calculations at the first stage with that essential difference carried out, that as final set MD sample $\{X(i,j)\}_V$ undertakes. From this final set samples on all set VA except for VA with a serial number (i,j) undertake. Among (n-1) samples there is a sample relative size of an interval of which changes of random variables the least. S.f.d. the sample it compared with s.f.d. final set MD.

Thus, naturally, there is a question on to what distribution to compare s.f.d. samples on two VA – with initial s.f.d. final set MD $F^*_\Sigma(X)$ or with s.f.d. the final set MD received to the most significant attribute $F^*_\Sigma(X)=F^*_{V,1}(X)$?

At the decision of this problem, it is necessary to start with following three axiomatic positions:

P 1. If $F^*_\Sigma(X)$ and $F^*_{V,1}(X)$ differ not casually
and if $F^*_{V,1}(X)$ and $F^*_{V,2}(X)$ differ not casually (11)
that $F^*_\Sigma(X)$ and $F^*_{V,2}(X)$ also differ not casually

P 2. If $F^*_\Sigma(X)$ and $F^*_{V,1}(X)$ differ casually
and if $F^*_{V,1}(X)$ and $F^*_{V,2}(X)$ differ not casually (12)
that $F^*_\Sigma(X)$ and $F^*_{V,2}(X)$ also differ not casually

In other words, the neglect casual character of a divergence $F^*_\Sigma(X)$ and $F^*_{V,1}(X)$ conducts to artificial distortion of size and understating of accuracy of an estimation of parameters of individual reliability, decrease in number of stages of classification of data, to the erroneous list significant VA

P 3. If $F^*_\Sigma(X)$ and $F^*_{V,1}(X)$ differ not casually
and if $F^*_{V,1}(X)$ and $F^*_{V,2}(X)$ differ casually (13)
that $F^*_\Sigma(X)$ and $F^*_{V,2}(X)$ also differ not casually

Positions (P1-P3) testify that at each i- th stage of classification distributions $F^*_{V,(i-1)}(X)$ should be compared and $F^*_{V,i}(X)$. At all subsequent stages of classification MD the calculations similar to the above-stated are spent, and come to the end provided that distinction s.f.d. $F^*_{V,(i-1)}(X)$ and $F^*_{V,i}(X)$ becomes casual

CONCLUSIONS

As a result of the lead researches methodical bases are developed:

- quantitative estimation of parameters of individual reliability of the equipment and devices of power supply systems;
- classifications set VA on significant and insignificant;
- ranging of significant attributes in ascending order the importance;
- transition of the decision of operational problems on the basis of ranging reliability of the equipment and devices at an intuitive level, to the decision on the basis of comparison of quantitative estimations of parameters of their individual reliability

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